

**THIRTEENTH MEETING OF THE UJNR  
PANEL ON FIRE RESEARCH AND SAFETY,  
MARCH 13-20, 1996**

**VOLUME 2**

---

Kellie Ann Beall, Editor

June 1997  
Building and Fire Research Laboratory  
National Institute of Standards and Technology  
Gaithersburg, MD 20899



**U.S. Department of Commerce**  
William M. Daley, *Secretary*  
**Technology Administration**  
Gary R. Buchula, *Acting Under Secretary for Technology*  
National Institute of Standards and Technology  
Robert E. Hebner, *Acting Director*

# **DURABLE AGENTS FOR EXPOSURE PROTECTION IN WILDLAND/URBAN INTERFACE CONFLAGRATIONS**

**Daniel Madrzykowski  
Gary L. Roadarmel  
Laurean A. DeLauter**

**National Institute of Standards and Technology  
Building and Fire Research Laboratory  
Gaithersburg, Maryland 20899**

## **ABSTRACT**

The objective of this study was to investigate the capability of "durable agents" to protect building exterior materials from ignition. The "durable agents" used in this study included: a protein-based, compressed air foam, and two different water thickeners, also known as gelling agents. Two exterior wall sections forming a corner were pre-treated with a "durable agent" and exposed to a 50 kW fire for 10 minutes. Flame extension on the exterior siding was recorded during the tests. This study demonstrated that durable agents applied to combustible exterior siding reduce the likelihood of ignition and flame spread.

## **1. BACKGROUND**

Wildland/urban interface conflagrations, such as the Oakland Hills fire in 1991 which destroyed 2889 homes [1], overwhelm the resources of the fire department. Some homes which were located in the path of the fire were saved, with little or no damage, due to the intervention of the fire department or the homeowners. The homes were saved by applying water to surfaces of the house throughout the time the home was exposed to a fire threat. Unfortunately, this method of protection requires fire fighters or homeowners to remain at the house, placing them in a dangerous situation and in the case of the fire fighters limiting the number of homes that they can protect. During large fire incidents the water supply may be diminished or depleted during the course of the fire.

A promising concept for protecting buildings in the path of an advancing wildland fire is to have the homeowner or fire department cover structures with a water based, compressed air foam or gelling agent prior to evacuating the area. Building and Fire Research Laboratory (BFRL) conducted a small scale study in 1988 on the ignition inhibiting properties of one type of Class A foam. Class A foam is intended for use as a suppression agent on "combustibles such as vegetation, wood, cloth, paper, rubber and many plastics"[2]. Class A foam may also be used for exposure protection. The results of the BFRL study indicated that compressed air, Class A foam exhibited an ignition-inhibiting capability twice that of an equal mass of water for untreated T1-11 textured plywood siding and the compressed air foam had a retention efficiency approximately 20 times that of water on the test samples [3].

The Class A foams are based on synthetic hydrocarbon surfactants which makes them good wetting agents. As a result, Class A foams tend to drain and break down rapidly relative to

protein based foams or water thickeners [4]. Therefore the protein based foams and water thickeners are referred to as "durable agents" to distinguish them from the Class A foams.

Experience from previous wildland/urban interface fires [5] shows that the fires which are spread by burning brands start small in areas where the brands can collect, such as under eaves or in corners. More data are needed to quantify the range of conditions which a wildland/urban interface fire can impose on a structure. However, if the structure can be protected from the thermal insult of a small fire for a short period of time, the chances of the structure igniting during a large fire incident may decrease dramatically.

## **2. EXPERIMENTAL APPROACH**

The objective of this study was to investigate the capability of durable agents to protect building exterior materials from ignition. The durable agents used in this study included: a protein-based, compressed air foam and two different water thickeners, also known as gelling agents.

The experimental structure used in this investigation was composed of two 1.2 m x 2.4 m high (4 ft x 8 ft) walls forming a corner, as shown in Figure 1. A partial attic assembly was positioned over the walls. The technique and the materials used in the construction of the corner are representative of construction techniques used in many parts of the United States. The overhang or eave of the structure is important because it traps heat, provides a path for flames into the attic, and allows ability of the agent to cling to the inverted surface to be examined. Each wall was built using 38 mm x 89 mm (nominally 2 in. x 4 in.) wood structural members. The vertical members were spaced 406 mm (16 in) on center. The void between the vertical members was filled with 89 mm (3.5 in) thick blankets of fiberglass insulation. The "interior" wall surface was constructed of 13 mm (0.5 in) thick sheets of gypsum board. In this study, three different "exterior" siding materials were used: 0.64 mm (0.025 in) thick aluminum, 16 mm (0.625 in) thick T1-11 textured plywood and 1.1 mm (0.045 in) thick vinyl. The design of the aluminum, and the vinyl sidings simulated 102 mm (4 in) wide clapboards. The soffit materials were consistent with the siding materials used for a given experiment.

A natural gas burner, 0.3 m (1 ft) on a side was located in the corner, 50 mm (2 in) away from the face of the walls and 0.3 (1 ft) above the floor. The 50 mm (2 in) gap between the wall and the burner was needed to reduce the flow of the durable agents onto the burner and to minimize any change in the characteristics of the fire. The gap was filled with ceramic fiber to minimize air entrainment on the wall sides of the burner. The burner was calibrated to provide a steady state 50 kW fire for the duration of each experiment.

Baseline experiments were performed with each exterior siding material (i.e., no agent application). The experiments were repeated with the durable agents applied to the combustible exterior siding materials. The agents were applied with commercially available equipment to the entire surface of the siding and underside of the eaves. The applications were made at 15 minutes prior to ignition. If the agent was successful in limiting flame spread with a pre-treatment time of 15 minutes, tests were conducted with a pre-treatment time of one hour. The experiments were conducted in a laboratory at temperatures between 21°C and 27°C and with relative humidities in the range of 45% to 70%.

The compressed air foam applications were made with protein-based foam concentrate batch mixed with water in a 3% solution (i.e., 97 parts water to 3 parts foam concentrate by volume). Although compressed air foam units can produce a wide range of foam expansions, for exposure protection, a stable foam is desired. A stable foam will drain water slowly, be composed of many tiny bubbles, and have the consistency of shaving cream. Foams with low expansions of 3 to 5, are wet and unstable. Foams with expansions of 40 to 50, are very stable, but very dry. Foams with expansions between 22 and 30 were used for the fire experiments in this study.

The water thickeners were proportioned at 3% with an in line eductor in a 38 mm (1.5 in) hose. Two types of nozzles were used during the experiments, a 13 mm (0.5 in.) smooth bore tip, and a fog nozzle.

### **3. EXPERIMENTAL RESULTS AND DISCUSSION**

The results of the baseline experiments ( i.e., no agent application) are given in Table 1. The time to initial flame extension and time to flame extension to the eave are the average times from three experiments. Initial flame extension was defined for the purposes of this study as combustion of the siding material and a measurable change in flame height relative to the flame height from the burner. Flame extension to the eave was recorded when the flames had extended to the top of the wall.

After 10 minutes of exposure to the 50 kW burner, aluminum siding had melted in the areas exposed to direct flame impingement. A smoldering fire had started on the structural members inside the wall, but there was no flame extension. On average, flames attached to the T1-11 siding and began spreading at approximately 200 seconds after ignition. The flames extended to the underside of the eave approximately 80 seconds later. The fire was limited to surface burning until the flames penetrated the vents in the eave and spread fire into the attic space.

The vinyl siding softened, deformed and charred prior to igniting. Small areas in the center of the flame impingement region charred and opened up which exposed the paperboard substrate within 60 seconds of ignition. Less than 90 seconds after ignition, the flames began to spread upward and within another 50 seconds the flames were into the attic space. A vinyl soffit was used with the vinyl siding. The soffit soften and dropped out leaving an open path for flame spread into the attic area.

The protein-based compressed air foam (CAF) when applied formed a 75 to 150 mm (3 to 6 in.) thick layer on the siding materials. The time to initial flame extension was almost twice as long with the foam applied to the T1-11 siding as compared to the untreated siding. There was no flame spread up to the eave throughout the duration of the test, as shown in Table 2. After the burner was shut off, the flames which had attached to the siding self extinguished. The foam proved even more effective on the vinyl siding only allowing flame extension in one out of the three cases. In that experiment initial flame extension occurred at 555 seconds after ignition and the flames extinguished within a minute after the burner was shut off.

The water thickener, referred to as Gel A in the Table 2, when applied to the siding left a coating approximately 6 to 12 mm (0.25 to 0.5 in.) thick. Immediately after application the gel began dripping and running down the surface of the siding. At the time of ignition, 15 minutes after application, the thickness of the agent on the siding had been reduced, with the run off pooled

in front of the walls on the floor. Mass retention was not characterized during these fire tests. The time to initial flame extension with Gel A was almost double the time for the untreated T1-11 siding. In two out of three cases the flame grew and extended to the eave, whereas in the foam cases, the flame never extended to the eave. For the tests with Gel A applied to vinyl siding flame extension to the eave and flame penetration into the attic occurred in all of the tests. There was no noticeable difference in the coating or the performance with the use of different nozzles.

Since the vinyl siding proved to be the most challenging scenario in this study, Gel B was only used with vinyl siding. Gel B when applied to the vinyl siding left a coating of approximately 6 to 12 mm (0.25 to 0.5 in.). Gel B appeared to flow down the siding at a slower rate than Gel A, therefore more agent remained on the siding at the time of ignition. In the three tests performed with a fifteen minute pre-treatment, Gel B prohibited flame extension. Again in the area of flame impingement, the vinyl deformed and charred however the fire never attached to the surface to extend the flame. Tests with a 60 minute pretreat time were also conducted with Gel B. Again no flame extension was observed.

#### **4. CONCLUSIONS**

This study demonstrates that durable agents applied to combustible exterior siding reduced the likelihood of ignition and flame spread, under laboratory conditions, i.e., no wind, no exposure to the sun, and moderate relative humidity. Not all of these agents performed equally, and differences in equipment requirements, environmental concerns, and usability need to be accounted for in a full evaluation of these agents. Further research needs to be conducted on mass retention and fire testing under more realistic weather conditions.

#### **5. REFERENCES**

1. Steckler, K.D., Evans, D.D., and Snell, J.E. Preliminary Study of the 1991 Oakland Hills Fire and Its Relevance to Wood-Frame, Multi-Family Building Construction, NISTIR 4724 Nat. Inst. Stand & Tech. Gaithersburg, MD, Nov. 1991.
2. NFPA 298, Standard on Fire Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas, 1994 ed. National Fire Protection Association, Quincy, MA. 1995.
3. Madrzykowski, D. Study of the Ignition Inhibiting Properties of Compress Air Foam, NISTIR 88-3880 Nat. Instit. of Stand & Tech. Gaithersburg, MD, Oct. 1988.
4. Rochna, R.R. Foam on the Range. Fire Chief Magazine, Vol. 38, No. 6, June 1994.
5. Tran, H.C., Cohen, J.D., and Chase, R.A. Modeling Ignition of Structures in Wildland/Urban Interface Fires. Proceedings, 1st International Fire and Materials Conference, Arlington, VA Sept 24-25, 1992.

Table 1. Flame extension times for untreated siding materials

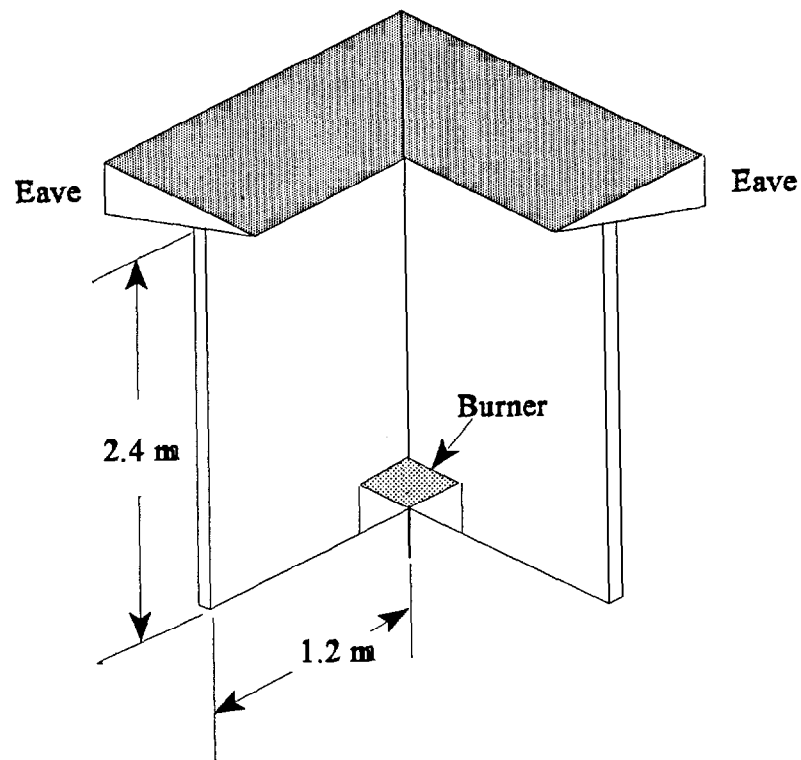
Siding Material	Time to Initial Flame Extension (s)	Time of Flame Extension to Eave (s)
Aluminum	no extension	no extension
T1-11 Plywood	203	288
Vinyl	82	130

Table 2. Flame extension times for siding materials treated with “durable agents,” 15 minute pretreatment times.

Siding Material w/agent	Time to Initial Flame Extension (s)	Time of Flame Extension to Eave (s)
T1-11 Plywood w/CAF A	392	no extension to eave
T1-11 Plywood w/Gel A	387	465*
Vinyl w/CAF A	555+	no extension to eave
Vinyl w/Gel A	255	427
Vinyl w/Gel B	no extension	no extension

\* Flame extended to the eave in 2 out of 3 experiments.

+ Flame extension was observed in 1 out 3 experiments.



**Figure 1** Schematic of Fire Test Arrangement